

## ORIGINAL ARTICLE

# Respirator-Fit Testing: Does It Ensure the Protection of Healthcare Workers Against Respirable Particles Carrying Pathogens?

M. C. Lee, MD; S. Takaya, MD; R. Long, MD; A. M. Joffe, MD

**OBJECTIVE.** Respiratory protection programs, including fit testing of respirators, have been inconsistently implemented; evidence of their long-term efficacy is lacking. We undertook a study to determine the short- and long-term efficacy of training for fit testing of N95 respirators in both untrained and trained healthcare workers (HCWs).

**DESIGN.** Prospective observational cohort study.

**METHODS.** A group of at-risk, consenting HCWs not previously fit-tested for a respirator were provided with a standard fit-test protocol. Participants were evaluated after each of 3 phases, and 3 and 14 months afterward. A second group of previously fit-tested nurses was studied to assess the impact of regular respirator use on performance.

**RESULTS.** Of 43 untrained fit-tested HCWs followed for 14 months, 19 (44.2%) passed the initial fit test without having any specific instruction on respirator donning technique. After the initial test, subsequent instruction led to a pass for another 13 (30.2%) of the 43 HCWs, using their original respirators. The remainder required trying other types of respirators to achieve a proper fit. At 3 and 14 months' follow-up, failure rates of 53.5% (23 of 43 HCWs) and 34.9% (15 of 43 HCWs), respectively, were observed. Pass rates of 87.5%-100.0% were observed among regular users.

**CONCLUSIONS.** Without any instruction, nearly 50% of the HCWs achieved an adequate facial seal with the most commonly used N95 respirator. Formal fit testing does not predict future adequacy of fit, unless frequent, routine use is made of the respirator. The utility of fit testing among infrequent users of N95 respirators is questionable.

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Respiratory protection programs, including fit testing of respirators, have been inconsistently recommended, legislated, and implemented throughout the United States, Canada, and other countries. Evidence supporting the efficacy of respirator-fit testing for healthcare workers (HCWs) is limited. Whether formal fit testing is required to achieve an acceptable fit is unknown. One study demonstrated that simply teaching HCWs the proper use of respirators leads to pass rates equivalent to those after formal fit testing.<sup>1</sup> Two studies have examined the short-term predictive value of fit testing: the National Institute for Occupational Safety and Health (NIOSH)<sup>2</sup> has shown, in human studies and mathematical modeling, that fit testing for N95 respirators reduces the average exposure to respirable particles from 33% to 4% of ambient levels; Coffey et al.<sup>3</sup> have shown that there is a high degree of protection at the time of fit testing.

The experience with SARS and the potential for the emergence of an influenza pandemic have further fueled the debate regarding respiratory protection. However, fit testing is both time-consuming and costly,<sup>1,4</sup> and its long-term efficacy in a

healthcare setting has never been evaluated; to our knowledge, there are no studies demonstrating that initial fit testing predicts an adequate fit during future use of the respirator. The objectives of our study were to determine (1) whether an acceptable respirator seal could be achieved without prior training or fit testing, (2) whether formal training and qualitative fit testing for personal protective respirators (ie, NIOSH-certified N95 respirators) could ensure an acceptable seal during future use by HCWs, and (3) whether regular use of a respirator by HCWs could improve consistency in achieving a facial seal.

## METHODS

To address objectives 1 and 2, we undertook a prospective observational cohort study of a population of healthy HCW volunteers. A selection of NIOSH-certified type-N95 filtering-facepiece particulate respirators (3M) was used. We adopted the validated qualitative fit-test protocol employing denatonium benzoate (Bitrex; Macfarlan Smith) in aerosol form, in accordance with the American National Standards Institute

From the Divisions of Infectious Diseases (M.C.L., A.M.J.) and of Pulmonary Medicine (R.L.), Department of Medicine, University of Alberta, Edmonton, Alberta, and the Division of Infectious Diseases, Department of Medicine, University of Saskatchewan, Saskatoon, Saskatchewan (S.T.), Canada.

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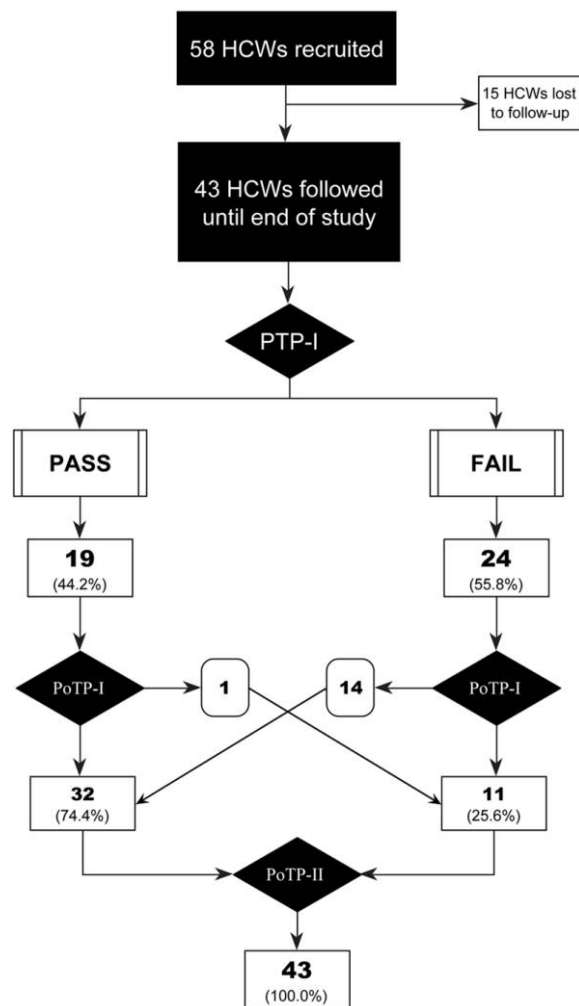


FIGURE 1. Flow chart summarizing the recruitment of healthcare workers (HCWs) to determine whether an acceptable respirator seal could be achieved without prior training or fit testing. Values are no. (%) of HCWs. PTP, pretraining phase; PoTP-I, posttraining phase using 3M 8210 respirators; PoTP-II, posttraining phase with tailored 3M respirators.

(ANSI) Z88.10 standard.<sup>5</sup> Our study was conducted in the Capital Health Region of the Province of Alberta, Canada, and was approved by the Health Research Ethics Board of the University of Alberta.

HCWs were enrolled if they had no prior experience with respirator-fit testing, were considered at risk of exposure to respirable particles carrying pathogens (thereby qualifying for our regional fit-test program), and provided informed consent. Participants underwent an initial denatonium benzoate taste-threshold screening at the beginning of each trial and prior to donning a respirator. After donning an enclosed hood, an HCW was subjected to a maximum of 3 sets of 10 sprays, each of a diluted form of denatonium benzoate (the fit-test solution was diluted 12.5 times), sequentially introduced inside the enclosure, until the HCW could detect the

bitter taste of the substance.<sup>5</sup> This screening defined the concentration to be administered during the subsequent qualitative fit test. Those HCWs who were not able to sense denatonium benzoate after 3 sets of 10 sprays were excluded from our study. HCWs were also excluded if they were unshaven (ie, males) or had eaten, drunk, smoked, or chewed something 15 minutes prior to the test.

Next, participants were asked to don a 3M 8210 NIOSH-certified N95 respirator without any instruction (hereafter, we refer to this as the “pretraining phase”). The respirator fit was then tested using the denatonium benzoate protocol.<sup>5</sup> The test was stopped if the HCW reported tasting denatonium benzoate or after the HCW completed the fit-test exercise regimen prescribed by the ANSI Z88.10 standard. Inability to taste the denatonium benzoate (implying a satisfactory facial seal) constituted a “pass” on the qualitative fit test.

Next, formal training and respirator-fit testing was conducted for all enrolled volunteer HCWs (hereafter, we refer to this as the “posttraining phase”). In this phase, the 3M 8210 respirator was used initially for all HCWs, to allow a comparison of pre- and posttraining pass rates and to allow an assessment of the impact of training. This phase of our study is hereafter referred to as the “posttraining phase using 3M 8210 respirators.” Instruction was provided for the following 5 standard steps,<sup>5</sup> to be performed each time a respirator was donned: (1) verifying the integrity of the respirator straps; (2) verifying correct strap placement, with the top strap around the crown of the head and the bottom strap at the base of the neck; (3) adjusting the nose-bridge piece correctly by moulding it down around the nose; and (4) performing the positive pressure checks and (5) performing negative pressure checks, with readjustment of the respirator until a complete seal is achieved. With the respirator donned properly, adequacy of the facial seal was evaluated by performing 7 successive 1-minute exercises inside the enclosure after the introduction of denatonium benzoate according to standard protocol.<sup>5</sup> This phase ended when the exercises were completed or a bitter taste was reported. As before, inability to taste the denatonium benzoate during the series of exercises constituted a “pass.” Those HCWs who failed to achieve an effective seal with the 3M 8210 respirator subsequently underwent fit-testing with other types of 3M respirators: (eg, models 8110S, 9210, 1860, 1860S, 1870, or 8271) until a pass was achieved (hereafter, we refer to this as the “posttraining phase with tailored 3M respirators”). The type of respirator used to pass the test was recorded, and participants were instructed to choose that specific type of respirator for all future uses of an N95 respirator.

Participants were invited back 3 and 14 months after the initial respiratory-fit testing, and the exercises described above were repeated to test for the appropriateness of the respirator donning technique and for the subsequent fit using the same protocol. Prior to the follow-up assessment, survey data were gathered on HCWs’ perceptions of the necessity of a regional fit-test program as well as on the frequency of respirator use

TABLE 1. Performance Record of Respirator-Fit Testing of 43 Healthcare Workers During the Different Phases of Our Study

Test result	Pretraining phase	Without respirator reminder				With respirator reminder	
		Posttraining phase using 3M 8210 respirator	Posttraining phase with tailored 3M respirators	3-month follow-up	14-month follow-up	3-month follow-up	14-month follow-up
Passed	19 (44.2)	32 (74.4)	43 (100.0)	20 (46.5)	28 (65.1)	27 (62.8)	33 (76.7)
Failed	24 (55.8)	11 (25.6)	0 (0.0)	23 (53.5)	15 (34.9)	16 (37.2)	10 (23.3)

NOTE. Data are no. (%) of healthcare workers.

and the level of confidence in passing a repeat fit-test challenge. During the initial part of the follow-up assessment, participants were asked to identify the type of respirator that they had successfully used the first time to pass the fit test. If the HCW chose the wrong respirator, that was recorded as a failed attempt, assuming that their facial configuration would not adequately fit other types of respirators. Following this first failed attempt, the HCW was reminded of the specific type of respirator that they were meant to use, according to previous records. This extra step (hereafter referred to as the “respirator-reminder step”) allowed us to adjust for the introduction of a name-tag respirator-reminder system, implemented regionally for HCWs during the course of our study, as well as to assess its overall impact. No prompts or instructions were provided during the remainder of the repeat fit-test challenge until the end, at which point all performance mistakes were recorded and participants were reinstructed in the proper donning techniques.

To address objective 3 (ie, determining whether regular use of a respirator by HCWs could improve consistency in achieving a facial seal), a second study population consisting of previously fit-tested nurses working in an inpatient tuberculosis unit was identified, and 11 nurses were recruited. This study population represented a full day’s complement of nursing staff in this unit and facilitated consistency and ease of follow-up during the test period. Each nurse underwent fit-testing 3 times at 2-week intervals during 6 weeks, in a manner identical to that described above. During the first 2 runs, fit testing was conducted without any reminders or instruction. The nurses were free to refer to the name-tag respirator-reminder system already implemented in our region by this time. After the second run of fit testing, and before to the third (at week 6), we instructed and reminded the nurses of the standard fit-checking steps necessary for successful respirator donning.

#### Statistical Calculations

The McNemar test was used to compare paired proportions between different time points of the study. A 95% confidence interval was used to define statistical significance.

#### RESULTS

To address objectives 1 and 2 (ie, determining whether an acceptable respirator seal could be achieved without prior training or fit testing, and whether formal training and qualitative fit testing for personal protective respirators could ensure an acceptable seal during future use by HCWs, respectively), a total of 58 volunteer HCWs were initially enrolled in our study. This was considered an adequate sample size, with an anticipated 10%–15% loss to follow-up. Forty-three (74%) of the 58 HCWs completed our study; 14 (24%) were lost to follow-up because they relocated out of the region, whereas 1 (2%) was excluded because of an inability to pass the qualitative fit-test with any of the available respirators. The baseline characteristics and initial performance characteristics of those HCWs lost to follow-up were not significantly different from those who completed our study (data not shown). The final group of 43 consisted of 17 medical residents, 1 attending staff physician, 7 medical students, 14 nurses, and 4 support staff; of these 43 HCWs, 29 were female, and 14 were male.

During the pretraining phase, 19 (44.2%) of the 43 HCWs passed the respirator-fit test using the 3M 8210 respirator without any instruction. During the posttraining phase using 3M 8210 respirators, an additional 13 (30.2%) of the 43 HCWs passed the test. Thus, 32 HCWs (74.4%) achieved an acceptable facial seal with the 3M 8210 respirator (Figure 1 and Tables 1 and 2). The remaining HCWs were successfully fitted with other types of respirators; to pass the test, 10 (23.3%) required the smaller 8110S model, and 1 (2.3%) required the 9210 model.

Passing the initial respirator-fit test did not correlate with passing the test 3 or 14 months later (Table 1), and significant performance failures were observed during these intervals, compared with those observed during end of the initial training and fit-testing phase (ie, during the posttraining phase with tailored 3M respirators). Accordingly, during a repeat fit-test challenge, only 20 (46.5%) of the 43 HCWs passed at 3 months ( $P < .001$ ), whereas 28 (65.1%) passed at 14 months ( $P < .001$ ). Moreover, neither rate was significantly different from the pretraining pass rate ( $P = .99$  at 3 months, and

TABLE 2. Differences in the Pass Rates of the 43 Healthcare Workers Who Underwent Respirator-Fit Testing, Between the Different Phases of Our Study

Baseline used	Baseline pass rate	Posttraining phase using 3M 8210 respirators			Posttraining phase with tailored 3M respirators			3-month follow-up			14-month follow-up		
		Difference	OR (95% CI)	P	Difference	OR (95% CI)	P	Difference	OR (95% CI)	P	Difference	OR (95% CI)	P
Without reminder													
Baseline 1	44.2%	+30.2%	13.0 (1.95–552.47)	.003	+55.8%	0	<.001	+2.3%	1.09 (0.44–2.92)	.99	+20.9%	2.500 (0.92–7.87)	.08
Baseline 2	100.0%	...	...	...	...	...	...	–53.5%	0 (0–0.174)	<.001	–34.9%	0 (0–0.28)	<.001
Baseline 3	46.5%	...	...	...	...	...	...	...	...	...	+18.6%	3.00 (0.91–12.76)	.08
With reminder													
Baseline 1	44.2%	...	...	...	...	...	...	+18.6%	1.00 (0.80–4.81)	.19	+32.5%	5.57 (1.64–30.18)	.004
Baseline 2	100.0%	...	...	...	...	...	...	–37.2%	0 (0.00–0.26)	<.001	–23.3%	0 (0.00–0.045)	.004
Baseline 4	62.8%	...	...	...	...	...	...	...	...	...	+13.9%	2.50 (0.72–10.92)	.18

NOTE. A 2-tailed *P* value was determined using the McNemar test. Baseline 1, pretraining phase; baseline 2, posttraining phase with tailored 3M respirators; baselines 3 and 4, at 3-month follow-up. CI, confidence interval; OR, odds ratio.

TABLE 3. Correlation of Following the 5 Standard Steps and Passing the Fit-Test Challenge, for 43 Healthcare Workers (HCWs) Who Underwent Respirator-Fit Testing

Follow-up, result	Strap integrity check	Correct strapping	Correct adjustment at bridge of nose	Positive pressure check	Negative pressure check
After 3 months					
Passed	8/27 (30)	20/27 (74)	20/27 (74)	7/27 (26)	4/27 (15)
Failed	7/16 (44)	5/16 (31)	3/16 (19)	1/16 (6)	1/16 (6)
<i>P</i>	.51	.01	<.01	.22	.64
After 14 months					
Passed	13/33 (39)	22/33 (67)	15/33 (46)	17/33 (52)	25/33 (76)
Failed	3/10 (30)	2/10 (20)	0/10 (0)	2/10 (20)	5/10 (50)
<i>P</i>	.72	.01	<.01	.15	.14

NOTE. Data are proportion (%) of HCWs, unless otherwise specified; a 2-tailed *P* value was determined using the McNemar test.

*P* = .08 at 14 months). Following a postperformance adjustment for the respirator-reminder step previously described, the pass rate improved from 46.5% to 62.8% (27 of 43 HCWs) at 3 months and from 65.1% to 76.7% (33 of 43 HCWs) at 14 months (Table 1). The improvement was significant at 14 months (*P* = .004).

To assess the contribution of each of the 5 standard steps (to be performed each time a respirator is donned) in passing the fit-test challenge, we tabulated the maneuvers performed (or not performed) at each step by each HCW. We then correlated the performance of each step with actual outcomes to determine its importance in predicting success or failure. When the 5 standard steps were analyzed individually, in comparison with the overall pass rate, we noted a significant trend supporting both the conclusion that "correct strapping" and "adjusting bridge of the nose correctly" are key steps in achieving an adequate respirator seal (Table 3).

Table 4 shows the results of a survey taken at each follow-up. Results of this survey demonstrate that confidence does not correlate with actual performance. Moreover, whereas 41 (95%) of the 43 HCWs felt that respirator-fit testing was necessary, only 23 (54%) of them felt they were likely to use the respirator on a regular basis.

Table 5 shows fit-testing performance by subgroup throughout the study period. Passing the fit test at the initial time point (without training) or occasional use of the respirator did not correlate with passing at 3 or 14 months, albeit a positive trend toward passing is seen with more regular use over time.

To address objective 3 (ie, determining whether regular use of a respirator by HCWs could improve consistency in achieving a facial seal), we enrolled and tested 11 nurses working on an inpatient tuberculosis unit. This group of nurses was among the first to be fit-tested with the initiation of our regional fit-test program in 2003, and they served as an internal control. All of the nurses had been fitted previously, and all used the respirators multiple times daily while at work. The test results are shown in Figure 2. The 4 nurses who repeatedly failed the first 2 test runs (at weeks 0 and 2) were

found to be using inappropriate respirators. All 4 nurses were using the model 8210 respirator as previously fit-tested. Failure to recall the respirator was not a factor here because the previously successfully fit-tested respirator was identified on a sticker on the back of their hospital identification badges. Two nurses reported having lost a significant amount of weight since their last respirator-fit test 2 years earlier. The other 2 nurses each had flat nasal bridges and erred by pinching the nose bridge of the respirator during every donning. All 4 nurses successfully passed subsequent challenges during fit testing with correct types of respirators (2 nurses used the 8110S model, and the other 2 used the 9210 model). Further analysis again demonstrated that both steps 2 and 3 (ie, "correct strapping" and "adjusting bridge of the nose correctly") were the strongest predictors of a successful fit (data not shown).

TABLE 4. Comparison of Survey Responses by Healthcare Workers (HCWs) Who Underwent Respirator-Fit Testing

Follow-up, variable	Proportion (%) of HCWs
After 3 months	
HCWs confident in passing fit-test challenge	
Who passed	9/27 (33)
Who failed	5/16 (31)
<i>P</i>	.99
After 14 months	
HCWs confident in passing fit-test challenge	
Who passed	25/33 (76)
Who failed	5/10 (50)
<i>P</i>	.14
Question	
Is fit testing necessary?	
Yes	41/43 (95%)
No	2/43 (5%)
Are you likely to use a respirator in your daily practice?	
Yes	23/43 (54%)
No	20/43 (46%)

NOTE. A 2-tailed *P* value was determined using the McNemar test.

TABLE 5. Performance Record of Respirator-Fit Testing of 43 Healthcare Workers (HCWs), by Subgroup

Subgroup of HCWs	Pretraining phase	Posttraining phase with tailored 3M respirators	3-month follow-up	14-month follow-up
HCWs who passed initially without training ( <i>n</i> = 19)				
Passed	19 (100)	19 (100)	10 (53)	16 (84)
Failed	0 (0)	0 (0)	9 (47)	3 (16)
<i>P</i>			.01	.62
HCWs who failed initially but passed with training ( <i>n</i> = 13)				
Passed	0 (0)	13 (100)	8 (62)	11 (85)
Failed	13 (100)	0 (0)	5 (38)	2 (15)
<i>P</i>			.07	.48
HCWs who failed initially and required another type of respirator ( <i>n</i> = 11)				
Passed	0 (0)	11 (100)	9 (82)	6 (55)
Failed	11 (100)	0 (0)	2 (18)	5 (45)
<i>P</i>			.48	.07
HCWs who made use of respirators in the workplace by the first 3 months ( <i>n</i> = 4)				
Passed	1 (25)	4 (100)	1 (25)	3 (75)
Failed	3 (75)	0 (0)	3 (75)	1 (25)
<i>P</i>			<.01	.25
HCWs who made use of respirators in the workplace by 14 months ( <i>n</i> = 10)				
Passed	4 (40)	10 (100)	6 (60)	8 (80)
Failed	6 (60)	0 (0)	4 (40)	2 (20)
<i>P</i>			.13	.48

NOTE. Data are no. (%) of HCWs, unless otherwise specified; a 2-tailed *P* value was determined using the McNemar test and was based on the total no. of HCWs for a particular subgroup who passed the posttraining phase.

## DISCUSSION

The global emergence of pathogens that can be carried by respirable particles and that have the potential to be transmitted to the respiratory tract (eg, the coronavirus causing SARS or the avian influenza A virus) has led to a renewed interest in respiratory protection programs for HCWs. The recently revised US Department of Health and Human Services Pandemic Influenza Plan<sup>6</sup> recommends that use of N95 respirators is "prudent" for all direct patient care activities. Another recent review suggests that aerosols (in addition to large droplets) play an important role in the transmission of influenza and calls for a reconsideration of what is appropriate personal protective equipment during influenza season or during an influenza pandemic,<sup>7</sup> although this interpretation has been challenged.<sup>8,9</sup>

During qualitative fit testing, the inability to taste or smell a noxious substance while wearing a respirator implies that an adequate facial seal has been achieved and that an individual is then protected against respirable particles carrying pathogens. In our study, 19 of the 43 HCWs passed the respirator-fit test using the 3M 8210 respirator without any instruction, resulting in a fit-test pass rate of 44.2% (Table 1). If all 58 HCWs who initially enrolled in our study are included, then 28 (48%) achieved a successful facial seal without training. This is relevant because it provides an estimate of the proportion of HCWs and non-HCWs that may be protected if 3M 8210 respirators were to be used without formal

fit testing (eg, in the event of a SARS-type outbreak or an environmental disaster, or for visitors to patients in airborne isolation in healthcare facilities). Moreover, this pass rate serves as a baseline for evaluation of a formal respirator-fit test program. If up to half of individuals achieve a successful seal utilizing a single type of respirator and with no instruction, how much better can we do with formal training and fit testing? Our study suggests that instruction alone (without fit testing) improves overall pass rates by 74.4% using the 3M 8210 respirator. Therefore, the only benefit to formal fit testing is that it identifies individuals whose facial features preclude use of the most common types of respirators. In our study, 11 (25.6%) of the 43 HCWs required an alternative respirator and would be considered the actual beneficiaries of a regional fit-testing program. This proportion is in agreement with that reported by NIOSH.<sup>2</sup> Hannum et al.<sup>1</sup> demonstrated a higher baseline pass rate of 79%, increasing to 91% after training and to 94% after formal fit testing.

When the HCWs in our study were retested 3 and 14 months after formal fit testing, pass rates were not statistically different from those seen at baseline (ie, before training and fit testing; Tables 12). Taken together, therefore, the results of our study and that of Hannum et al.<sup>1</sup> suggest that fit testing offers limited benefit, in both the short and long term.

Most of the HCWs in our study did not have occasion to use the N95 respirator regularly, and those who did showed a tendency to pass the test (Table 5), suggesting that frequent

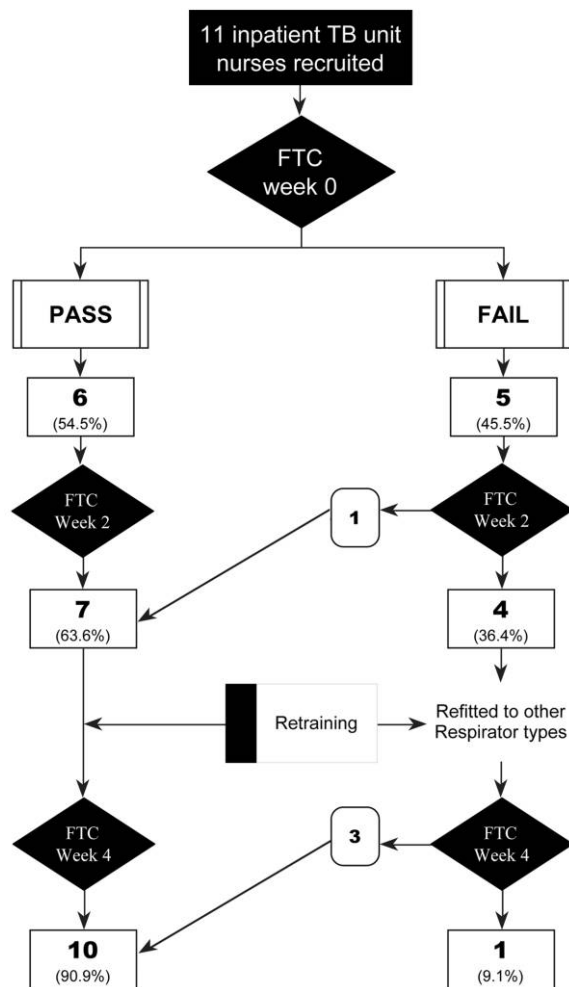


FIGURE 2. Flow chart summarizing the recruitment and follow-up of nurses working on an inpatient tuberculosis (TB) unit to determine whether regular use of a respirator could improve consistency in achieving a facial seal. Values are no. (%) of nurses. FTC, fit-test challenge.

use after initial training may favor achieving an adequate fit. To further explore whether regular use of an N95 respirator leads to improved results, we enrolled 11 nurses working in an inpatient tuberculosis unit who typically utilized the N95 respirator multiple times per day while at work. Although 2–3 years had elapsed since their last respirator-fit testing and training, they exhibited a high pass rate. Discounting the 4 nurses who were using inappropriate types of respirators, 6 of the 7 remaining nurses (85.7%) passed on the first test run, whereas all 7 (100%) passed on the second and third tests 2 and 4 weeks later. This suggests that practice improves performance when it comes to donning N95 respirators. Moreover, the observation that weight gain or loss over time—in our study, 2 nurses lost weight between tests—can adversely affect a previously successful fit suggests that repeated fit testing should be required and that the recording

of a HCW's weight during fit-testing sessions might be an additional required piece of information. Strategies for self-reporting, compared with periodic regional fit testing, would address this issue. Further studies regarding how and to what degree weight gain or loss can adversely affect respirator fit would also be helpful. Finally, the key steps of “correct strapping” and “adjusting bridge of the nose correctly” remained important strong predictors of a successful fit, as observed in the group of 43 HCWs.

Five standard steps are routinely recommended to ensure that a seal is consistently achieved with every use of an N95 respirator. Despite training, however, only a minority of HCWs actually remembered and performed all 5 steps properly; less than 5% of our test subjects repeatedly passed all fit-test challenges. Of the 5 recommended steps, correct strapping and adjusting of the nose-bridge piece appeared to be the most important steps in predicting adequate seal and protection (Table 3). Frequent errors in donning N95 respirators have been demonstrated in both occupational<sup>10</sup> and nonoccupational<sup>11</sup> settings.

During our study, it was also noted that many HCWs could not recall the appropriate type of respirator to use when they were retested, and many did not appear to appreciate the fact that fit testing is specific for an individual type of respirator. Significant improvement in the pass rate was noted after adjusting for this respirator-reminder step (Tables 1 and 2). It became clear that a respirator-reminder system is critical and that the application of a sticker to the back of the user's hospital identification badge with the name of the appropriate respirator proved to be a simple strategy. Making different types of respirators easily accessible and posting visible reminders of the key steps necessary for proper donning may also help ensure optimal performance.

Judging from the results shown in Table 4, a formal respiratory protection program provided a sense of reassurance and confidence to HCWs that their health and safety were considered paramount while they provided patient care. Unfortunately, the confidence felt by the HCWs in our study did not correlate with the degree of protection during formal fit testing, because the HCWs were unable to judge whether they had achieved an adequate respirator seal or whether they were therefore protected from respirable particles carrying pathogens after donning a respirator.

The limitations of our study include its small size. Although 58 HCWs were enrolled in our study, only 43 could be located 14 months later. This is a reflection of the mobility of, and instability in, the HCW workforce and adds complexity to any respiratory protection program. Our study utilized qualitative respirator-fit testing to assess the adequacy of the facial seal. This is the most common technique employed for fit testing but is limited. In particular, it relies on the individual user's ability to taste or smell the noxious agent, and this reliance could potentially contribute to errors in the probability of failing the denatonium benzoate test with an adequately protective respirator ( $\alpha$ ) and in the probability of

passing the denatonium benzoate test with an inadequately protective respirator ( $\beta$ ).<sup>12-14</sup>

The observations noted in our study challenge the current strategy for fit testing, which, in our region, is mandated every 2 years for all HCWs with direct patient care responsibility. Our findings question the need for repeated fit testing of HCWs who utilize respirators on a frequent (ie, daily) basis, because their success rates were very high. On the other hand, different strategies may be required for HCWs who utilize respirators infrequently. Alternative teaching techniques or reminder sessions (ie, 2 or 3 times a year) may be needed, because pass rates of 50%–75% in this group are suboptimal. The feasibility and cost-effectiveness of these approaches need to be examined carefully. Finally, our data suggest that fit testing may be most useful for the initial screening of people whose facial features preclude the use of the most common types of respirators (which, in our region, was the model 3M 8210 respirator).

In summary, 44%–48% of HCWs were able to achieve a successful facial seal utilizing the most common type of respirator without formal training. Respirator-fit testing of large numbers of HCWs, most of whom would use a respirator infrequently, may not achieve the desired degree of respiratory protection, because a 25%–50% failure rate was noted during long-term follow-up. Moreover, HCWs cannot tell with any accuracy whether they have achieved an adequate facial seal after donning their respirator. Finally, regular use of the respirator may improve success. A larger scale study of HCWs employing quantitative fit testing (in addition to qualitative fit testing) and long-term follow-up is needed to further clarify the role that fit testing plays in a healthcare setting. Careful analysis of efficacy and cost-effectiveness of different fit-test strategies is also needed.

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Address reprint requests to M. C. Lee, MD, University of Alberta Hospital,

2E4.16, Walter C. McKenzie Centre, 8440, 112 Street, Edmonton, AB T6G 2B7, Canada (maocheng@ualberta.ca).

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